ESTD Engineering Science & Technology Division

MEMS Bio-Chemical Transducer

Calorimetric MEMS sensor array platform

In response to the growing interest in the areas of non-homogeneous chemical reactions and microsensors, we propose a revolutionary approach to signal transduction in which we not only sense chemical reactions with a fine-mesh pixilated array (200 μm pixel spacing), but also control the local reaction rates with the mesh elements. This combines our expertise in the areas of CMOS integrated circuit processing, MEMS fabrication, chemical and biochemical sensing, and advanced theoretical chemistry. This technology will provide an interface between conventional ICs and chemical and biochemical reactions by not only monitoring, but also providing highly localized control of the reactions. Direct application to a variety of sensor requirements as well as fledgling disciplines including bioelectronics will be feasible. We intend to develop this concept as an integrated circuit and then apply it in two areas: (1) sensing and control of chemical and biological reactions such as those produced by glucose and cholesterol; and (2) real-time analyses of non-linear oscillating chemical reactions. This technology has been issued **U. S. Patent No. 6,436,346 (August, 2002).**

The Technology

All physical, chemical, and biological reactions proceed with some change in heat and/or order. Access to the thermal component of these reactions could provide for a universal control and sensing mechanism where these reactions could be monitored and switched on or off. Further, control in multiple dimensions can allow for spatial patterning or imaging of chemical or biochemical reactions. Such an approach is possible with the use of microfabricated thermal sensors and controllers.

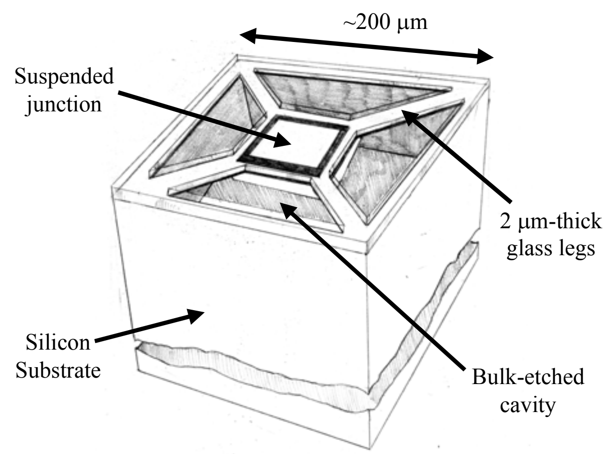

Figure 1. Single element of a bulk-etched thermal sensor array

We have designed a micromachined sensor that can be fabricated in standard bulk-well CMOS processes by utilizing an extra etch step. A single element of the array is shown in Figure 1. As heat is released or absorbed, the diode temperature will change with a corresponding change in diode voltage. The thermal mass of the device and the conductive loss to the chip are greatly lowered by removing the silicon surrounding the device. Consequently, reactions that occur on or near the surface of the device can be monitored with **picojoule** precision, far better than with existing sensors. Additional integration with resistive heating elements or Peltier-style temperature controllers would allow controlled heating or cooling of each device. By careful control of the temperature, specific reactions can be either enabled or inhibited. Arraying of these structures would allow control of a variety of reactions or permit the realization of detailed spatial patterns of micro-heating to be monitored in real time.

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Applications

Numerous applications of such an integrated thermometric array can be envisioned. Biological macromolecules, such as proteins or nucleic acids, could be directly attached to these structures and their reactivity directly monitored and controlled. Specific micro-sensors for glucose or cholesterol could be created for blood monitoring. Antibodies could be attached for sensing of particular metabolites for pharmacological dose monitoring or even for detection of biowarfare agents. Additionally, this may have eventual application to chemical or biochemical **logic** devices where reaction states can be switched and monitored in parallel. This can also be useful for directed, *in-situ* microsynthesis. Libraries of chemical compounds could be constructed and functionally assessed enabling, for example, rapid drug discovery, materials research, or advanced catalyst development.

Features

- **MicroSensor Array – Tens of sensors on a single substrate**
- **Capable of mapping inhomogeneous reactions**
- **General analytical utility**
- **Variety of applications – vapors, catalysis, biochemicals, pharmaceuticals**

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